May 29, 1923. 1,456,744

H. L. TANNER

CONTROLLING MECHANISM FOR STABILIZING GYROSCOPES

Filed Oct. 4, 1917 3 Sheets-Sheet 1

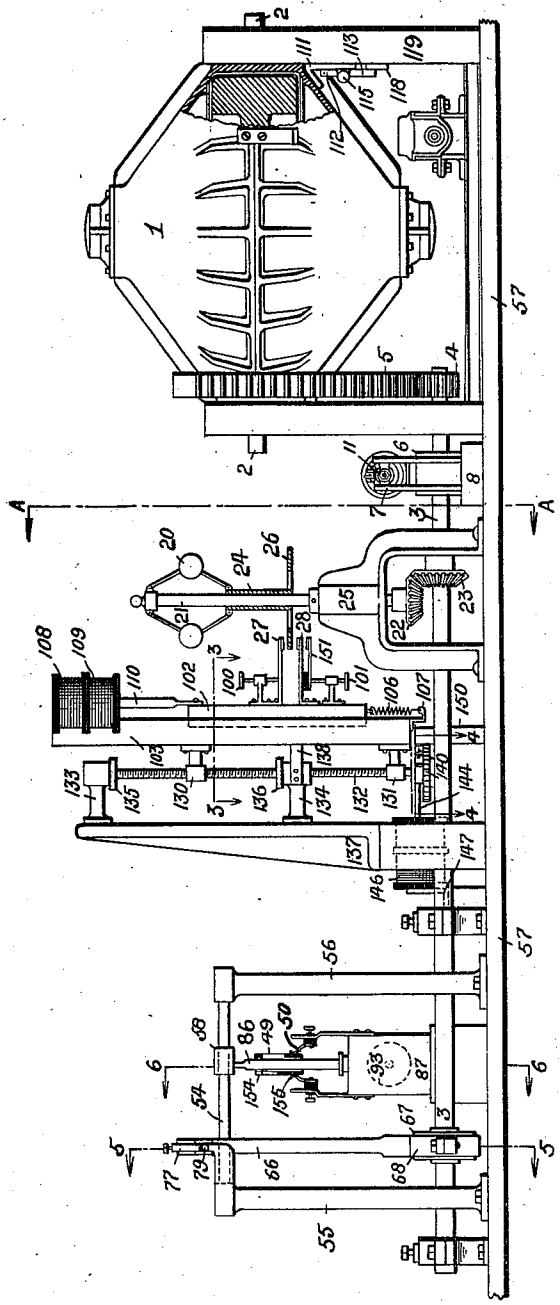


Fig. 1.

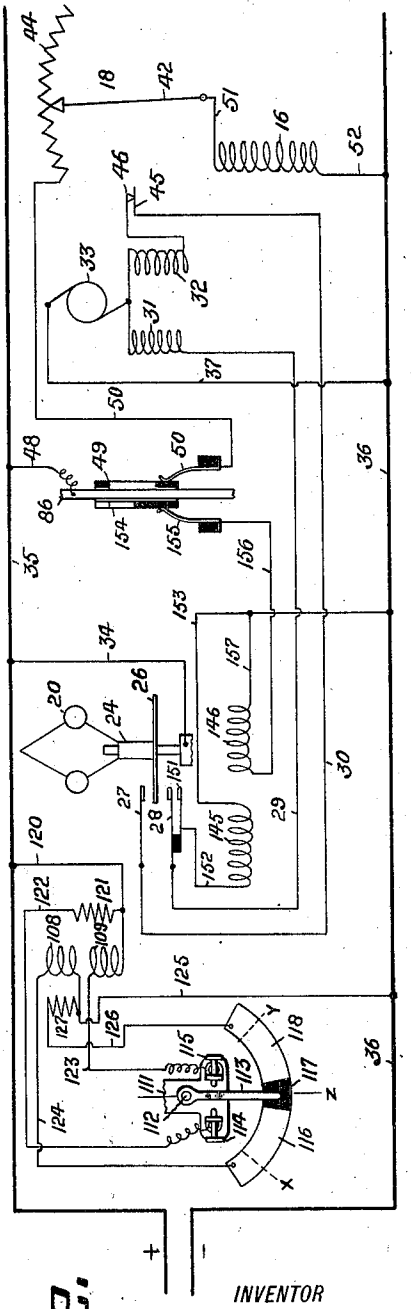


Fig. 2.

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Fig. 3.

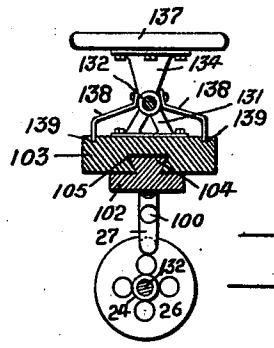


Fig. 4.

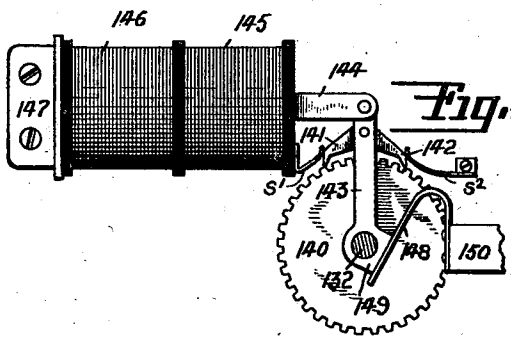


Fig. 5.

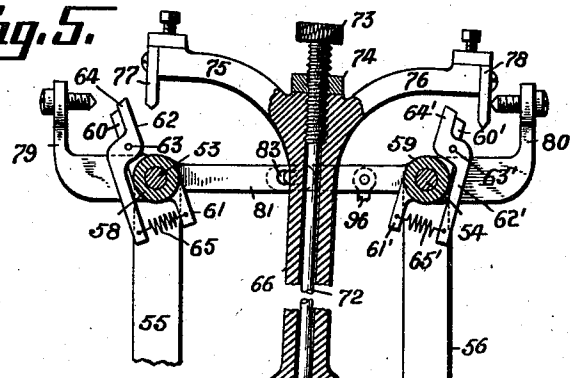
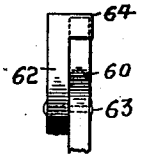


Fig. 5a.



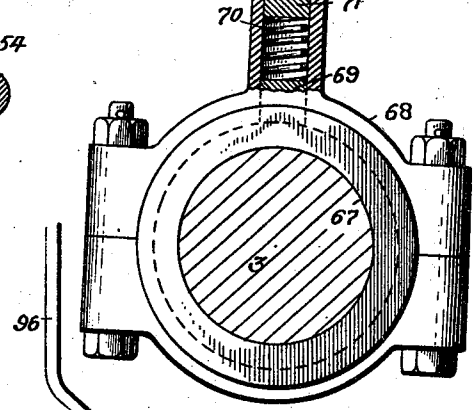


Fig. 6.

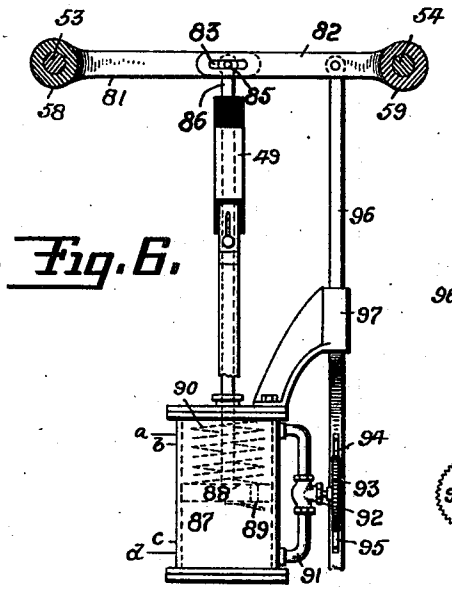




Fig. 7.

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Fig. 8.

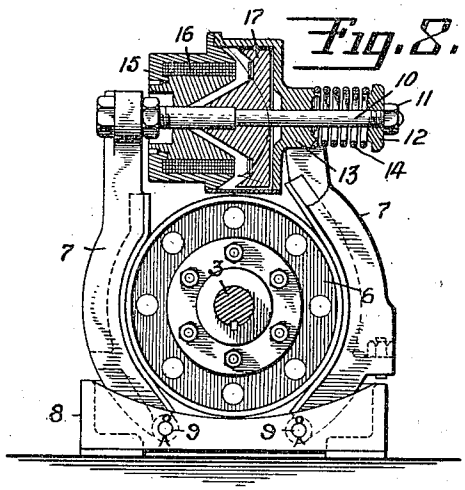


Fig. 9.

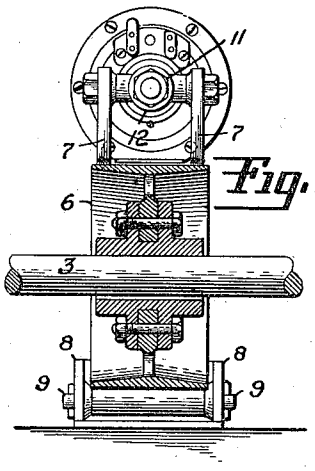


Fig. 10.

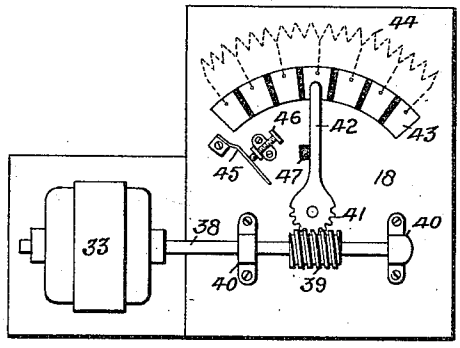
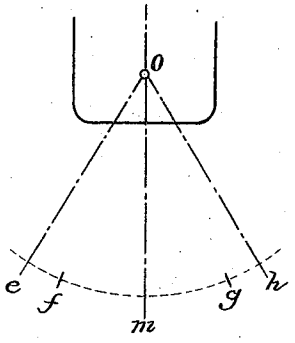


Fig. 11.



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Patented May 29, 1923. 1,456,744

UNITED STATES PATENT OFFICE.

HARRY L. TANNER, OF BROOKLYN, NEW YORK, ASSIGNOR TO THE SPERRY GYROSCOPE COMPANY, OF BROOKLYN, NEW YORK, A CORPORATION OF NEW YORK.

CONTROLLING MECHANISM FOR STABILIZING GYROSCOPES.

Application filed October 4, 1917. Serial No. 194,646.

To all whom it may concern:

Be it known that I, HARRY L. TANNER, a citizen of the United States of America, residing at 1144 East 19th Street, Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Controlling Mechanism for Stabilizing Gyroscopes, of which the following is a specification.

This invention relates to gyroscopic stabilizers of the type usually employed to stabilize ships, although the invention is capable of other uses. More specifically the invention may be said to relate to a passive type of stabilizer with added automatic controls imparting many of the properties of the active type without the control gyros and other complicated apparatus of the active type.

It is well known that in the ordinary passive system of stabilization a portion of the energy of stabilization is exerted when the ship is nearly at its extreme positions of swing or oscillation. As a result this portion of the energy, practically speaking, does not tend to decrease the amplitude of the roll but merely to change the period. My invention aims to prevent the expenditure of this portion of the energy at this particular point, or points, of the roll by locking the gyro against precession until after the ship has travelled a predetermined portion of the period from its extreme positions of roll and preferably also by bringing the precession to a low speed at a predetermined time before the ship reaches its extreme position of roll.

Another important object is to cause the precession of the gyro to maintain a practically constant predetermined rate during each half cycle of roll.

It is well known to those skilled in the art that the amplitude of roll of a ship varies for different conditions of the sea and accordingly the speed of precession in order to stabilize properly should be varied for different conditions of the sea. Various systems of control for stabilizers have been devised for effecting this result. In these systems it will be found that the speed of precession varies in a jerky manner. In my system I aim to avoid this jerky action, i. e., to effect a smooth control of the speed of precession so as to expose the operating parts to minimum strain.

A further object is to provide a system with the above enumerated objects and advantages of a small number of parts and employing no gyros other than the main stabilizing gyro or gyros.

Other objects and advantages will appear as the description of the system proceeds.

Referring to the drawings which illustrate what I now consider the preferred form of my invention:

Fig. 1 is an elevational assembly of one form of my invention, certain details being omitted for the sake of clearness and the control apparatus beyond line A—A being on a much larger scale than the gyroscope and brake.

Fig. 2 is a wiring diagram of my invention.

Fig. 3 is a section on the line 3—3 of Fig. 1.

Fig. 4 is a section on the line 4—4 of Fig. 1.

Fig. 5 is a section on the line 5—5 of Fig. 1.

Fig. 5ª is a fragmentary detail of a part of the mechanism illustrated in Fig. 5.

Fig. 6 is a section on the line 6—6 of Fig. 1.

Fig. 7 is a fragmentary detail of a part of the mechanism illustrated in Fig. 6.

Fig. 8 is a front elevation, partly in section, of a form of brake forming a part of my invention.

Fig. 9 is a side elevation partly in section, of the struction shown in Fig. 8.

Fig. 10 is an elevation of a motor controlled rheostat utilized in my improved system.

Fig. 11 is a diagram employed in explaining a part of the operation.

Referring to Fig. 1 it will be seen that as in other systems I employ a stabilizing gyroscope 1 mounted for precession about the axis 2—2 which axis is placed in a fore and aft or athwartship direction depending on whether it is desired to stabilize against pitch or roll of the ship. For the sake of simplicity it will be assumed that it is desired to stabilize against roll.

Before entering into the description of the specific details of the physical embodiment of my invention hereinafter disclosed, a recapitulation and restatement of the principal objects to be accomplished will prove helpful. Referring to Fig. 11 let it be assumed that the arc, e, h, represents half the period of roll of the ship for a given condition of the sea, e and h representing reversal of roll, and suppose the ship is starting to swing at e. Precession is to be started at f where e, f, represents a predetermined portion of the period. Precession is to take place at a predetermined constant speed during the time interval f, g, and the speed of precession is to be materially reduced and in effect the gyroscope brought to rest during the interval g, h. Furthermore the above mentioned constant speed of precession from f to g is to be adjusted to fit the condition of the sea.

Thus it becomes necessary to provide some device or mechanism for fixing the points e, f, g and h with reference to the roll of the ship no matter what the period of the latter may be due to the condition of the sea. The device provided by me for accomplishing this function is comparatively simple and makes use of no auxiliary gyro or gyros. This device which may be termed a control device will be hereinafter more specifically described.

In addition to this control device I provide precession speed control mechanism and centralizing mechanism as will later appear in detail.

Control device.

The control device may assume the form shown in Figs. 1, 2, 5, 6, and 7. A pair of parallel shafts 53, 54 are journaled for rotation in uprights 55, 56, 55′, 56′ secured to the base 57. The shafts 53, 54 have fixedly secured thereto hubs 58 and 59 respectively. The hub 58 has integrally connected therewith a pair of oppositely extending arms 60, 61 to one of which, 60, a lever 62 is pivoted at 63. The upper end of lever 62 is provided with a laterally extending lug 64 (see Fig. 5ª) adapted to engage the upper end of the arm 60. A spring 65 secured to the lower ends of lever 62 and arm 61 tends to maintain the lug 64 in engagement with the arm 60. The elements 60′ and 65′ on the hub 59 correspond to elements 60 to 65 on the hub 58 and need no further description. For the purpose of oscillating the shafts, 53, 54 at desired times a T-shaped friction arm 66 is frictionally engaged with the shaft 3. The particular structure forming this friction connection is shown as comprising a friction collar 67 fixedly secured to the shaft 3 and loosely surrounded by a split collar 68 secured to the lower end of the T-shaped arm 66. The leg of the last mentioned arm is shown hollowed out to form a guide for a friction block 69 adapted to engage the friction collar 67. For the purpose of adjusting the frictional force between the block 69 and collar 67 means may be provided for varying the pressure of the block on the other of the last named elements. These means may assume the form of a spring 70 interposed between the block 69 and a vertically slidable block 71 which is provided at its upper face with a conical seat to receive the lower conically shaped end of a rod 72, all of which elements may be located within the hollow leg of the T-shaped arm 66. The rod 72 is engaged at its upper end by a set screw 73 which engages in the upper end of the leg or vertical portion of the T-shaped arm. Obviously by turning the set screw 73 the pressure adjustment above referred to may be effected and an adjustment once made may be maintained by tightening the lock nut 74.

The horizontal arms 75 and 76 of the T-shaped member 66 are each provided with a downwardly extending lug 77 and 78 each adapted to engage a corresponding one of the levers 62 and 62′ on movement of the member 66 away from central position and thereby oscillate the shafts 53 and 54. More specifically, when the member 66 moves to the left the lug 77 engages the lever 62 to oscillate the shaft 53 in a counter-clockwise direction but the lug 78, in spite of the fact that it engages the lever 62′, does not oscillate shaft 54 as the lever 62′ moves away from the arm 60′. Conversely when the member 66 moves to the right shaft 54 is oscillated by the T-shaped arm but not the shaft 53.

The shaft 3, above mentioned, is shown coupled to the gyro 1 by means of segmental gear 5, secured to the gyro casing, and a pinion 4 meshing with gear 5 and secured to shaft 3. Obviously the shaft 3 will reverse whenever precession of the gyro 1 reverses.

It will be seen that one or the other of the shafts 53, 54 is oscillated every time the shaft 3 reverses direction of rotation and the shaft 3 reverses every time precession of the gyro 1 reverses or in other words one or the other of the shafts 53, 54 is quickly oscillated or tripped immediately after the ship passes through the extreme positions of roll or oscillation. Stops 79 and 80 may be fixedly secured to the uprights 55, 56 for the purpose of limiting the throw of the T-shaped member 66. By virtue of this above described structure the movement of the shafts may be utilized to establish, what may be termed, reference points e and h (see Fig. 11). Thus shafts 53, 54 may have secured thereto the arms 81 and 82, each provided with a slot 83, at their free ends. A vertically movable rod 86 may be connected to the arms 81 and 82 by a pin 85 passing through slot 83.

As the rod 86 is kicked up at each reversal of precession it is obvious that if some mechanism is provided for causing it to drop

a predetermined constant distance at a practically uniform rate it may be utilized quite readily to fix the points *f* and *g* (see Fig. 11) with respect to points *e* and *h*.

The mechanism preferred at present by me, for causing the rod 86 to drop as above indicated is shown in detail in Figs. 6 and 7.

A dash pot 87 is shown as mounted on the base 57 and contains a piston 88 secured to the lower end of the rod 86. A check-valve 89 on the piston permits unimpeded upward movement of the rod 86 but closes on downward movement of the latter to retard its descent. A spring 90 may be provided within the cylinder 87, and above the piston 88, to aid in returning the piston to downward position. The upper and lower ends of the cylinder are shown connected by a by-pass 91 containing a needle or other regulating valve 92. By adjusting the latter the by-pass 91 may be restricted or opened whereby the time taken by the piston 88 to drop may be controlled. Mechanism is provided for automatically adjusting the position of the needle valve 92. This mechanism may assume the form of a ratchet wheel 93, mounted on the spindle of the valve 92 and cooperating with a pair of oppositely directed spring pawls 94, 95 mounted on the rod 96. The last mentioned element is shown slidably mounted in a bracket 97, secured to the dash-pot cylinder, and is pivotally connected at its upper end to the arm 82.

The operation of the control device, as thus far described is as follows:

Precession of gyro 1 will reverse every time the ship tends to swing in a reverse direction and every time precession reverses the rod 86 is rapidly kicked up. This causes the pawl 95 to engage the ratchet wheel 93, while the piston 88 is traveling from *b* to *a*, to step the said ratchet wheel one notch in such a direction as to open the valve 92 wider. The piston 88 starts to descend, being impeded by the trapped fluid in the bottom of the cylinder. When the piston reaches point *c*, the pawl 94 engages the ratchet wheel 93 and if the piston 88 is kicked up again, by reversal of precession, as soon as it reaches the point *d*, the pawl 94 will have rotated the wheel 93 one notch in a direction opposite to that due to pawl 95. In short if the piston 88 travels from *a* to *d* between two successive reversals of precession the valve 92 will be unchanged in condition for the down-stroke of the piston. If the piston is dropping too slowly; i. e., if it fails to reach the point *d* before precession reverses, the pawl 94 does not cause the ratchet wheel 93 to restrict the passage of valve 92 so that in the next down-stroke of the piston the fluid impedance is less and the piston will consequently drop more quickly. This will continue until a stable condition is reached when the piston drops from *a* to *d* in the interval between two reversals of precession. If the piston drops too quickly; i. e., if it travels past *d* before precession reverses, the valve 92 will be closed a greater extent (due to the fact that pawl 94 now rotates the wheel 93 two notches) than it was opened by the pawl 95 so that the impedance to the down stroke will be increased and the descent slowed down. This would continue until a stable condition is again reached. Thus, at any time the piston 88 will drop from *a* to *d* at a practically uniform rate and in a total length of time equal to the average time interval between each two of the immediately preceding reversals of precession. In other words, the piston 88 drops at such a rate as to fit the condition of the sea.

As electrical means for effecting the precession speed control are preferred by me at present I provide the rod 86 with contacts 49 and 154 adapted to engage the contacts 50 and 155 respectively at points in the downstroke of said rod 86 corresponding to the points *f* and *g* of Fig. 11. The contacts 50 and 155 may be adjustably secured to the cylinder 87.

Precession-speed control mechanism.

As stated in connection with Fig. 11, at various times in the operation the gyro 1 is to be locked against precession, at other times the speed of precession is to be kept constant and this constant speed is to be adjusted to fit the condition of the sea. I accomplish these functions in the present specific embodiment by employing a brake, a speed responsive device for controlling the braking torque, and means for changing the effective relationship between the brake and speed responsive device, which elements will be taken up in detail in the order named.

A preferred type of brake is one in which a magnet acts in opposition to a spring. Either the magnet or the spring could be utilized to apply the braking torque. I prefer to utilize the form of brake shown in Figs. 1, 8 and 9 which is biased to braking position; i. e., the spring constantly tends to apply the brake.

The brake is shown as comprising a drum 6, keyed or otherwise secured to the shaft 3 and a plurality of brake shoes 7, 7 each secured at one end to a fixed base block 8 by means of pins 9. One of the shoes 7 has secured thereto at its free end one end of a rod 10, the other end of said rod being screw threaded whereby a nut 11 may be screwed on said rod to provide an abutment for a collar 12 also mounted on the rod. The other shoe 7 is shown as provided at its free end with a member 13 through which the rod 10 passes and which member 13 forms a seat for one end of a compression

spring 14 which abuts at its other end the collar 12. It will be apparent that the spring is constantly tending to urge the shoes 7 to braking position. The spring 14 is of such strength that it is capable of exerting a force, through the brake, sufficient to lock the gyro against precession at the desired time.

One form of electro-magnetic means for effecting partial or total release of the brake is illustrated in Figs. 8 and 9. The member 13 is shown as cup-shaped and has secured thereto an annular shell 15 of magnetic material which carries a solenoid 16. The armature 17 of the electro-magnet is secured to the other shoe 7 through the rod 10. Obviously sufficient energization of the solenoid 16 will separate the shoes 7 and release the brake.

The above described brake may also be utilized, not only to lock and release the gyro for precession, but to control the speed of precession. Thus by varying the strength of current through the solenoid 16 the pull exerted between the solenoid and its armature 16 and consequently the effective thrust of the spring 14 on the shoes 7 may be varied.

The speed responsive device is shown as a governor 20 driven by precession of the gyroscope and controlling the energization of the solenoid 16 in a manner hereinafter more specifically described. The governor 20 is shown as secured to a vertical shaft 21, rotatable in a bearing 25, and provided with a beveled gear 22 meshing with a similar bevelled gear 23 on the shaft 3. The governor comprises a metallic sleeve 24 connected to the governor balls and positioned in accordance with the speed of rotation of shaft 21 and therefore in accordance with the speed of precession of the gyroscope.

While the governor 20 might be connected in various ways to control the solenoid 16 I prefer at this time to use the connections and instrumentalities illustrated. The sleeve 24 is shown as provided with a disk 26 forming a movable contact adapted to cooperate with a plurality of relatively stationary adjustable contacts 27, 28. The contacts 27, 28 are connected by means of wires 29 and 30 to a corresponding field winding 31 or 32 of the motor 33, the field windings 31 and 32 being reversely wound. The disk contact 26 is shown connected through the shaft 21 and conductor 34 to a line wire 35 and the free armature terminal of the motor 33 is shown connected to the other line wire 36 by means of a wire 37.

The reversible motor 33 is employed to adjust a rheostat 18 electrically connected to the brake solenoid 16, the electrical connections being hereinafter more specifically described. The motor 33 is shown as having a long shaft 38 journaled in bearings 40, on the rheostat 18, and provided between the bearings 40 with worm 39. While I am aware that various types of rheostats might be employed the particular one illustrated (see Fig. 10) comprises a pivoted arm 42 provided at one side the pivot with a segmental rack 41 meshing with worm 39, and at the opposite side with a prolonged portion co-operating with a series of contacts 43 connected to taps of a resistance 44. A switch comprising contacts 45 and 46 may also be provided on the rheostat 18 to be opened by the arm 42 when the latter is at the extreme left hand position on contacts 43. The contact 45 is a spring contact fixed to the rheostat casing and biased to engage, normally, the fixed contact 46. When the arm 42 approaches the extreme left hand position a lug of insulation 47, provided on said arm 42, engages the free end of spring contact 45 to cause it to be disengaged from the other contact 46. The contacts 45, 46, are placed in series with the wire 30 for a purpose which will appear later.

As shown in Fig. 2 the rheostat is connected in series with the brake solenoid 16 through the following circuit: from line wire 35 through wire 48, contacts 49 and 50, wire 50′, resistance 44, arm 42, wire 51, brake solenoid 16, wire 52 to supply wire 36.

With the above described structure and connections it is apparent that if contacts 49 and 50 are open the solenoid 16 is deenergized and the brake applied to lock the gyro 1 against precession. This, of course, takes place when the gyroscope approaches the limit of it precessional movement—i. e., at point "g" in Fig. 11, the brake operating to bring the gyroscope quickly to rest and the brake remaining locked until the point "g" is reached on return roll of the ship. Assuming that contacts 49 and 50 are closed the precession will be kept at a speed corresponding to the position of the contacts 27, 28 with relation to disc 26. Thus if the precession is above a predetermined speed, disc 26 engages contact 27, to energize motor 33 in such a direction as to cause the motor to operate rheostat arm 42 to cut in more resistance 44 and thereby increase the braking torque. This will slow the precession down. Similarly, if the speed of precession drops below this predetermined constant speed, the contact 28 is engaged and the speed is allowed to pick up.

For changing the effective relationship between the speed responsive device and the brake I provide means for shifting the position of the contacts 27, 28. By elevating contacts 27, 28, the permitted constant speed of procession is raised while the latter is lowered by lowering said contacts.

The last mentioned means may assume the form illustrated and constructed substantially as follows: The base 103 which carries contacts 27, 28 is shown provided

with two internally screw-threaded brackets 130, 131 which are engaged by a screw-threaded rod 132. The rod 132 is mounted on an upright post 137, secured to base 57, by means of journal brackets 133 and 134, said rod being rotatable in the journals but prevented from vertical movement by means of collars 135, 136. Rotation of the base 103 may be prevented by providing guide strips 138, (see Fig. 3) on the journal bracket 134, which engage slots 139 provided in one side of the said base 103. Obviously by rotating the rod 132 the base 103 and contacts 27, and 28 are moved in a vertical direction either up or down according to the direction of rotation of the rod.

The mechanism for actuating the rod 132 may assume the form of an electro-magnetically actuated pawl and ratchet as illustrated. The ratchet wheel is fixedly secured to the lower end of the rod 132 and is adapted to be engaged by one or the other of pawls 141, 142 pivotally connected to and extending in opposite directions from the arm 143. The last mentioned element is loosely pivoted at one end on rod 132 and is pivotally connected at its free end to the plunger 144 of electromagnets 145, 146 which are in turn mounted on the base 57 by means of an end bracket 147. The arm 143 may be biased to normal position by means of a spring 148 secured to a bracket 150, which in turn is mounted on base 57, the said spring engaging a squared, flat portion 149 on the arm 143. The electromagnets are so designed that if energized successively, even though simultaneously remaining energized, the one first energized will hold the plunger 144 in attracted position. Springs s^1 and s^2 may be provided to prevent actuation of the ratchet wheel 140 by either of the pawls when the latter are returning to neutral position.

The contacts and connections for controlling the energization of magnets 145, and 146 may assume the form illustrated. A contact 151, which I term a limit contact, is shown mounted on the contact 28, but insulated therefrom, and is adapted to be engaged only when the governor drops to a comparatively low speed. This contact is adapted to energize the magnet 145 through the following circuit: starting with line wire 35, through wire 34, disc 26 contact 28, contact 151, wire 152, magnet 145, wire 153 to opposite line wire 36. For controlling energization of the magnet 146 I have provided contacts 154, 155 in all respects the same as contacts 49, 50, except that the former are preferably adapted to engage when the rod 86 is the same distance from its lowermost position of normal travel as the said rod was from its uppermost position of normal travel when contacts 49, 50 closed. The circuit of the magnet 146 is as follows: starting with line wire 35 through wire 48, rod 86, contact 154, contact 155, wire 156, magnet 146, wires 157 and 153 to line wire 36.

The operation of my system as thus far described may best be understood by again referring to Fig. 11. To repeat: the arc e, h represents half the period of actual roll of the ship with a given condition of sea. This period of actual roll should be distinguished from the natural period of the ship, which is a constant, as the former varies with different conditions of sea. The rod 86 will drop from a to d in one-half the period of actual roll so that the contacts 49, 50 may be so located on rod 86 as to close at a point corresponding to f in Fig. 11. It will be clear that the ratio of e, h to e, g is a constant. Now assuming that the roll starts at e, the rod 86, which has been kicked up by reversal of precession, starts to drop. After a time e, f the contacts 49, 50 close to release the brake to allow precession of the gyro 1 to begin. This precession is maintained at a constant speed by the speed responsive device 20, etc. If the contacts 27, 28 are in such position as to allow a rate of precession too high for the condition of the sea existing at that time the precession will drop to such an extent, prior to the closure of contacts 154, 155, as to cause contact to be established between disc 26 and contact 151. This sequence of operation will cause the magnet 145 to be energized before the magnet 146 which would cause the rod 132 to be rotated to lower base 103 and contacts 27, 28, so that the permitted constant speed of precession would be changed to a lower value. On the other hand if precession takes place at too low a speed for the existing condition of sea the magnet 146 will be energized ahead of magnet 145 and contacts 27, 28 will be shifted upwardly so as to cause the permitted constant speed of precession to be raised. Thus the cycle of operation summed up is as follows: Starting with the ship at one extreme position of roll (e) the gyro 1 is locked against precession for a predetermined portion of the half period (e, f), the gyro 1 is then permitted to precess, at a constant speed of a value which will correspond to the condition of the sea, until a point g is reached which occurs preferably, before the roll reverses at h. At this point, contact 49 is disengaged from contact 50 and the circuit through solenoid 16 broken, thereby applying the brake with the maximum force; the brake then remaining locked for the reason above described until the point "g" is again reached on the return oscillation of the ship. The operation for the roll of the other half period (h to e) is similar to that of the above described half cycle.

A stabilizer designed as above described acts much more efficiently than the ordinary

passive type and is simpler in design than the active type as all control gyros are dispensed with.

Centralizing mechanism.

The centralizing means, referred to above, comprises a means for shifting contacts 27, 28 and a switch, which I term a centralizing switch for controlling this means. This means acts independently of the mechanism for shifting the base 103 and may be constructed as follows: The slide 102, on which the contacts 27, 28 are mounted, is shown as provided with a dovetail extension 104 (see Fig. 3) on one side thereof which is slidable in a dovetail groove 105 in the base 103. The slide is biased to lower position, with respect to its base 103, by gravity and if desirable the action of gravity may be supplemented by a spring 106 secured at its upper end to the lower end of slide 102 and at its lower end to a lug 107 provided at the lower end of base 103. A pair of electro-magnets 108, 109 are shown provided on the upper end of the base 103 and are provided with a plunger 110 secured at its lower end to the upper end of slide 102. These last mentioned magnets are so arranged that if either is energized alone the solenoid plunger will be raised but on simultaneous energization the plunger is undisturbed as the two magnets then neutralize each other.

The centralizing switch may assume the form illustrated, in which a lug or arm 111 provided on the frame of the gyro 1 carries, pivotally connected thereto at 112, a switch arm 113. Contacts 114, 115 are also mounted on but insulated from the arm 111 and segmental contacts 116 and 118 are mounted on, but insulated from, one of the bearing brackets 119 of the gyro.

The centralizing switch and its magnets 108, 109 may be connected electrically as follows: Starting with line wire 35, a wire 120 leads to a resistance 121 which in turn is connected to contact 114 by means of wire 122. The opposite contact 115 is connected to magnet 109 by means of a wire 123 and the other end of said magnet 109 is connected to wire 120. The contact segment 116 is connected to one end of magnet 108 by means of wire 124, the other end of said magnet being connected to the line 36 by means of wire 125. The remaining contact segment 118 is connected, by means of wire 126, to the resistance 127 which, in turn is connected to wire 125.

The operation of the precession centralizing feature of my invention is substantially as follows: Suppose that precession is taking place between x and y (Fig. 2) and that the lug 111 is in the position shown and traveling to the left. The switch arm 113 will engage segment 116 and be moved into engagement with contact 115 thus closing a circuit from line wire 35, through wire 120, magnet 109, wire 123, contact 115, arm 113, segment 116, wire 124, magnet 108 and wire 125 to line 36. Magnets 108, 109 both being energized neutralize each other and no pull is exerted on plunger 110, (see Fig. 1). When precession reverses at x the arm 113 is thrown away from contact 115 and into engagement with contact 114 to break the last described circuit and to establish the following circuit: from line wire 35 through wire 120, resistance 121, wire 122, contact 114, arm 113, segment 116, wire 124, magnet 108 and wire 125 to line wire 36. Magnet 108 being energized alone raises plunger 110 and slide 102 to raise the contacts 27, 28 thereby permitting the precession to speed up from x to z.

When the lug 111 reaches segment 117 the last mentioned circuit is broken to cause plunger 110 to drop as both magnets are now deenergized. When precession reverses at y the arm 113 is thrown over to contact 115 and the following circuit established: from line wire 35 through wire 120, magnet 109, wire 123, contact 115, arm 113, segment 118, wire 126, resistance 127 and wire 125 to line 36. Energization of the magnet 109 alone, causes the same effect as energization of magnet 108 alone, i. e., raising the permitted speed of precession.

Summing up the last described cycle: When the precession is from extreme outward position to the normal central position the precession is speeded up, but when the precession is away from central position precession takes place at the usual speed. As a result any tendency to precess more to one side of center than to the other, will be overcome.

In accordance with the provisions of the patent statutes, I have herein described the principle of operation of my invention, together with the apparatus, which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means. Also, while it is designed to use the various features and elements in the combination and relations described, some of these may be altered and others omitted without interferring with the more general results outlined, and the invention extends to such use.

Having described my invention, what I desire to secure by Letters Patent is:

1. In combination, a stabilizing gyroscope, means for locking said gyroscope against precession and means for rendering said locking means ineffective to lock said gyroscope at a predetermined point in a precession-causing roll, said second named means being controlled by said gyroscope.

2. In combination, a stabilizing gyro-

scope, means for locking said gyroscope against precession and means controlled by said gyroscope for releasing the latter between one extreme position and mid position of a precession-causing roll.

3. In combination, a stabilizing gyroscope, means controlled by said gyroscope for locking the latter against precession for a predetermined portion of a roll and means for maintaining the speed of precession of said gyroscope practically constant for a larger portion of the roll.

4. In combination, a stabilizing gyroscope, means controlled by said gyroscope for maintaining the speed of precession of said gyroscope practically constant for the major portion of a half period of roll and means controlled by said gyroscope for varying the value of said constant speed on variation of the amplitude of roll of the ship.

5. In combination, a stabilizing gyroscope, means controlled by said gyroscope for maintaining the speed of precession of said gyroscope practically constant for the major portion of a half period of roll and means controlled by reversal of precession of said gyroscope for fixing the value of said constant speed.

6. In combination, a stabilizing gyroscope, a speed responsive device connected to said gyro, means connected to said speed responsive device for controlling the speed of precession of said gyroscope and means including a member actuated on reversal of precession of said gyroscope for changing the effective relation between said device and said first named means.

7. In combination, a stabilizing gyroscope, a speed responsive device actuated by precession of said gyroscope, means controlled by said device for controlling the speed of precession of said gyroscope and means controlled by said gyroscope for changing the effective relation between said device and said first mentioned means.

8. In combination, a stabilizing gyroscope, a speed responsive device actuated by precession of said gyroscope, means controlled by said device for controlling the speed of precession of said gyroscope and means, including a control device actuated by said gyroscope, for changing the effective relation between said device and said first mentioned means.

9. In a ship stabilizing system, a gyroscope, a control device actuated in one direction at each reversal of precession of said gyroscope, means for causing said control device to move at a practically uniform rate in the opposite direction between two reversals of precession and means for maintaining the extent of movement of said device in the last mentioned direction practically constant although the number of reversals of precession, of said gyroscope, per unit of time may vary.

10. In combination, a stabilizing gyroscope, a control device comprising a movable element, means for moving said element in one direction upon reversal of precession of said gyro means for causing said element to move in the opposite direction at a substantially uniform speed and means comprising a part actuated upon reversal of precession of said gyroscope for adjusting the value of the above mentioned speed.

11. In combination, a stabilizing gyroscope, a control device comprising a movable element, means for rapidly actuating said element in one direction on reversal of precession of said gyroscope, means for retarding the movement of said element in the opposite direction, a member controlling said retarding means and means actuated by said gyroscope for actuating said member in opposite directions.

12. In combination, a gyroscope, a dash-pot, means for rapidly elevating the piston of said dash-pot on reversal of precession of said gyroscope, means including a valve for controlling the flow of fluid from one end of said dash-pot to the other and means actuated on reversal of precession of said gyroscope for operating said valve.

13. In combination, a gyroscope, a control device movable at a practically uniform speed and a practically constant extent during successive reversals of precession of said gyroscope and means for controlling the speed of precession of said gyro, said means being controlled by said device.

14. In combination, a gyroscope, a control device, means for causing said device to move a practically constant distance at a practically uniform rate during successive reversals of precession of said gyroscope and means controlled by said device for locking said gyro against precession.

15. In combination, a gyroscope, a control device, means for causing said device to move a substantially constant distance at a substantially uniform speed during successive reversals of precession of said gyroscope, a speed responsive device actuated by precession of said gyroscope, means controlled by said speed responsive device for controlling the speed of precession of said gyro and means controlled by said control device for changing the effective relation between said speed responsive device and said speed controlling means.

16. In combination, a gyroscope, a control device, means for causing said device to move a substantially constant distance at a substantially uniform speed during successive reversals of precession of said gyroscope, a speed responsive device actuated by precession of said gyroscope, means con-

trolled by said speed responsive device for controlling the speed of precession of said gyro, means for controlling said speed controlling means from said control device and means controlled by said control device for changing the effective relation between said speed responsive device and said speed controlling means.

17. In combination, a stabilizing gyroscope, a control device actuated by reversal of precession of said gyroscope, means for preventing precession of said gyroscope and connections between said device and said means.

18. In combination, a stabilizing gyroscope, a control device actuated by reversal of precession of said gyroscope, means mechanically connected to said gyroscope for controlling the speed of precession of the latter, a speed responsive device connected to said gyro and to said speed controlling means and means controlled by said control device for shifting the connections between said speed responsive device and said speed controlling means.

19. In combination, a stabilizing gyroscope, a speed responsive device driven at a speed proportional to the speed of precession of said gyroscope, means controlled by said device for controlling the speed of precession of said gyroscope, precession centralizing means connected to said gyroscope and means controlled by said centralizing means for changing the effective relation between said device and said speed controlling means.

20. In combination, a stabilizing gyroscope, means including a part actuated by said gyroscope for controlling precession of said gyroscope, means, including a speed responsive device driven at a speed proportional to the speed of precession of said gyroscope, for controlling the speed of precession of said gyroscope and precession centralizing means including a part actuated by precession of said gyroscope.

21. In combination, a stabilizing gyroscope, a control device actuated on reversal of precession of said gyroscope, a centralizing device actuated by said gyroscope, a speed responsive device driven at a speed proportional to the speed of precession of said gyroscope, means connected to said gyroscope for controlling the speed of precession of the latter, connections between said speed responsive device and said means, and means controlled by said control device and by said centralizing device for changing the effective relation between said speed responsive device and said first named means.

22. In combination, a stabilizing gyroscope, means for braking the precession of said gyroscope and means including a centralizing device governed by said gyroscope for causing the braking torque applied when said gyroscope is precessing toward central position to differ from that applied when the precession is away from central position.

23. In combination, a stabilizing gyroscope, precession retarding means connected thereto, a device actuated by precession of said gyroscope and means including said device for causing the torque exerted by said retarding means when said gyroscope is precessing toward central position to differ from that exerted when the precession is away from central position.

24. In combination, a stabilizing gyroscope, an electro-magnet, means connected to said gyroscope for energizing said magnet when said gyro is precessing in one direction on one side of central position and means for deenergizing said magnet when said gyro is precessing in the opposite direction on the same side of central position.

25. In combination, a stabilizing gyroscope, an electro-magnet, a contact, means for causing said electro-magnet to shift said contact when said gyro is precessing in one direction on either side of central position and means for causing said electro-magnet to release said contact when said gyro is precessing in the opposite direction on the same side of central position.

26. In combination, a stabilizing gyroscope, a switch connected to said gyroscope, a plurality of electro-magnets and means for energizing any one or all of said electro-magnets, said means being controlled by said switch.

27. In combination, a stabilizing gyroscope, a control device actuated by reversal of precession of said gyroscope and a precession controlling brake controlled by said device.

28. In combination, a passive stabilizing gyroscope, a control device and a centralizing device controlled by said gyroscope, precession controlling means and connections between said devices and said means.

29. A ship stabilizing system comprising a passive stabilizing gyroscope, precession limiting means connected thereto and means actuated by said gyroscope and operating through said other means for synchronizing the precession of the gyroscope with the roll of the ship.

30. In combination, a stabilizing gyroscope, a speed responsive device actuated by said gyroscope, a centralizing device actuated by said gyroscope and precession retarding means controlled by said devices.

31. In combination, a stabilizing gyroscope, a control device, a speed responsive device, a centralizing device, each of said devices being actuated by said gyroscope and a precession controlling brake controlled by said devices.

32. In combination, a stabilizing gyroscope, a speed responsive device actuated by said gyroscope, precession controlling means, connections between said device and means, a control device actuated by said gyroscope and means controlled by said control device for shifting said connections.

33. In combination, a stabilizing gyroscope, a speed responsive device actuated by said gyroscope, precession controlling means, connections between said device and means, a centralizing device actuated by said gyroscope and means controlled by said centralizing device for shifting said connections.

34. In combination, a stabilizing gyroscope, a speed responsive device actuated by said gyroscope, precession controlling means, connections between said device and means, a centralizing device actuated by said gyroscope, a control device actuated by said gyroscope and means controlled by said centralizing and control devices for shifting said connections.

35. In combination, a stabilizing gyroscope, a control device actuated by reversal of precession of said gyroscope, a switch actuated by said device, an electro-magnetic precession controlling brake and means including said switch for energizing and deenergizing the brake magnet.

36. In combination, a stabilizing gyroscope, a control device actuated on reversal of precession of said gyroscope, a switch actuated by said device, a centralizing switch actuated by said gyroscope, an electro-magnetic precession controlling brake and means including said switches for controlling the energization of the brake magnet.

37. In combination, a stabilizing gyroscope, a control device actuated on reversal of precession of said gyroscope, a switch actuated by said device, an electro-magnetic precession controlling brake, means including said switch for energizing and deenergizing the brake magnet, a speed responsive device actuated by said gyroscope and means including said last mentioned device for controlling the strength of current through said magnet.

38. In combination, a stabilizing gyroscope, an electro-magnetic precession controlling brake, a circuit for energizing the brake magnet, means for varying the strength of current through said magnet, a speed responsive device actuated by said gyroscope and a centralizing switch actuated by said gyroscope, said means being controlled by said switch and said device.

39. In combination, a stabilizing gyroscope, an electromagnetic precession controlling device, a speed responsive device actuated by said gyroscope, electrical contacts cooperating with said device, means including said contacts for controlling the energization of the brake magnet, a control device actuated by said gyroscope and means controlled by said control device for shifting the position of said contacts with respect to said speed responsive device.

40. In combination, a stabilizing gyroscope, an electromagnetic precession controlling device, a speed responsive device actuated by said gyroscope, electrical contacts cooperating with said device, means including said contacts, for controlling the energization of the brake magnet, a centralizing switch actuated by said gyroscope and means controlled by said centralizing switch for shifting the position of said contacts with respect to said speed responsive device.

41. In combination, a stabilizing gyroscope, an electromagnetic precession controlling device, a speed responsive device actuated by said gyroscope, electrical contacts cooperating with said device, means including said contacts for controlling the energization of the brake magnet, a centralizing switch actuated by said gyroscope and means controlled by said control device and by said centralizing switch for shifting the position of said contacts with respect to said speed responsive device.

42. In combination, a passive stabilizing gyroscope, a control device actuated upon reversal of precession of said gyroscope and precession controlling means controlled by said device.

43. In combination, a stabilizing gyroscope, means controlled by said gyroscope for opposing precession for a predetermined portion of a roll and means for maintaining the speed of precession of said gyroscope practically constant for a larger portion of the roll.

44. In combination, a stabilizing gyroscope, a control device actuated by reversal of precession of said gyroscope, means for controlling precession of said gyroscope and connections between said device and said means.

45. In combination, a stabilizing gyroscope, a control device actuated by reversal of precession of said gyroscope, and precession controlling means controlled by said device.

46. In combination, a stabilizing gyroscope, a speed responsive device actuated by said gyroscope, a centralizing device actuated by said gyroscope, and precession controlling means controlled by said devices.

47. In combination, a stabilizing gyroscope, a device for synchronizing said gyroscope with the roll of the ship controlled by said gyroscope and means controlled by said synchronizing device for varying the speed of precession of said gyroscope for the purpose specified.

48. A ship stabilizing system comprising a passive stabilizing gyroscope, and means

for limiting the period of precession of the gyroscope to the phases of maximum velocity of oscillation of the ship.

49. A ship stabilizing system comprising a stabilizing gyroscope, means for limiting the periods of precession of said gyroscope to the phases of maximum velocity of oscillation of the ship, and means for maintaining the speed of precession substantially constant during the periods of precession.

In testimony whereof I have affixed my signature.

HARRY L. TANNER.